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IMPACT OF DEFOLIATION BY WESTERN SPRUCE BUDWORM BOISE AND PAYETTE NATIONAL FORESTS AND INTERMINGLED FEDERAL, STATE AND PRIVATE LANDS 1978

Forest Insect and Disease Management
State and Private Forestry
USDA-Forest Service
Boise, Idaho

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BOISE AND PAYETTE NATIONAL FORESTS
AND INTERMINGLED FEDERAL, STATE AND PRIVATE LANDS

1978[1, 2]

INTRODUCTION

A damage assessment survey was conducted in 1978 to update information on effect of defoliation by western spruce budworm to commercial forest stands in the west central portion of Idaho. The data were collected to use in the Addendum to the 1978 Environmental Impact Statement on Western Spruce Budworm. The Addendum will consider options available to combat the western spruce budworm in 1979 and the years following. Additional information on western spruce budworm for the Boise-Payette infestation is given in Knopf et al. 1979, 1977a, and 1977b, and Ollieu et al. 1977a and 1976b.

The western spruce budworm survey was conducted by personnel from the Boise Field Office, Forest Insect and Disease Management, and the Boise National Forest, with the assistance from the Payette National Forest, State of Idaho, Boise Cascade Corporation, FI&DM, Missoula, and the Pacific Southwest Forest and Range Experiment Station.

METHODS

Stands chosen for the impact evaluation were located both within and in close proximity to the 1978 area of defoliation shown in Figure 1. Type maps and color resource photography were used to identify grand fir and Douglas-fir stands that were accessible by road or trail. Initially, over 100 stands between 15 and 120 acres were chosen, from which 36 stands were randomly selected to distribute sample sites throughout the area of infestation. An additional twelve stands were selected from the Boise National Forest compart-mental exam to help complete some forest areas and Analysis Units. A dis-cussion and definition of Analysis Units are given at the end of this Methods Section.

This survey was more complex than the one completed in 1977. Information was gathered for the Region 1 "INDIDS" program[3], and also for integration into the stand prognosis and other models of the CANUSA Spruce Budworm Program. As a result, data were taken on the CANUSA data form[4], with additional information recorded on the "INDIDS" data form.

[1] Prepared by Ronald E. Eldridge and Max Ollieu, Forest Insect & Disease Management, USDA-Forest Service, Boise, Idaho.

[2] Prepared by Wayne Bousfield, Forest Insect & Disease Management, USDA-Forest Service, Missoula, Montana.

[3] R-1 Forest Insect & Disease Management Damage Survey Handbook.

[4] Instruction Handbook for Data Collection, Impact and Assessment Working Group, CANUSA-West.

The five Analysis Units are shown below with assigned numerical rating range and defoliation intensity:

Analysis Unit	Numerical Rating(%)	Defoliation Intensity Over Time
1	0	none
2	1-6	light
3	7-12	moderate
4	13-22	heavy
5	22	severe

RESULTS

The impact survey sampled 48 stands in 1978 over the commercial forest affected by western spruce budworm in the Boise-Payette infestation area. Analysis Units 3, 4, and 5 represented stands moderately, heavily, and severely defoliated for the infestation period and contained 25 of the 48 stands sampled. Analysis Unit 5 had the lowest number of stands sampled (3) because few areas fell in that category at that time. It takes at least eight years of heavy defoliation to reach Analysis Unit 5. However, with each year of defoliation, more and more stands fall into this group.

Variable Plots (Trees $\geq$ 5" dbh)

Analysis Unit 1, which represents those stands outside current areas of defoliation as determined from aerial sketch mapping, had some light defoliation when visited on the ground. Most of the trees were green and undamaged. Analysis Unit 2 stands (light defoliation) contained mostly trees in the green to moderate defoliation categories with very little top kill or mortality. Analysis Units 3, 4, and 5, which represent stands in areas which experienced moderate, heavy and severe defoliation over the period of infestation are presented in Table 1. Twenty-five stands included in this group, averaged 203 trees and 22,607 board feet per acre. Within these three Units, defoliation caused some degree of top killing to 14.8 percent of the trees (30 T/A). Mortality attributed to western spruce budworm was 2.5 percent of all trees (5 T/A) on the variable plots amounting to 152 board feet per acre.

Grand fir in variable plots in Analysis Units 3, 4, and 5 comprised 37 percent of the trees and 38 percent of the volume sampled. Approximately 9 percent of all plot trees were top-killed grand fir. Considering top kill of tree species individually, 23 percent of all grand fir were top killed, 21 percent of all subalpine, 17 percent of all Engelmann spruce, and 4 percent of all Douglas-fir. Again these are trees $\geq$ 5" dbh.

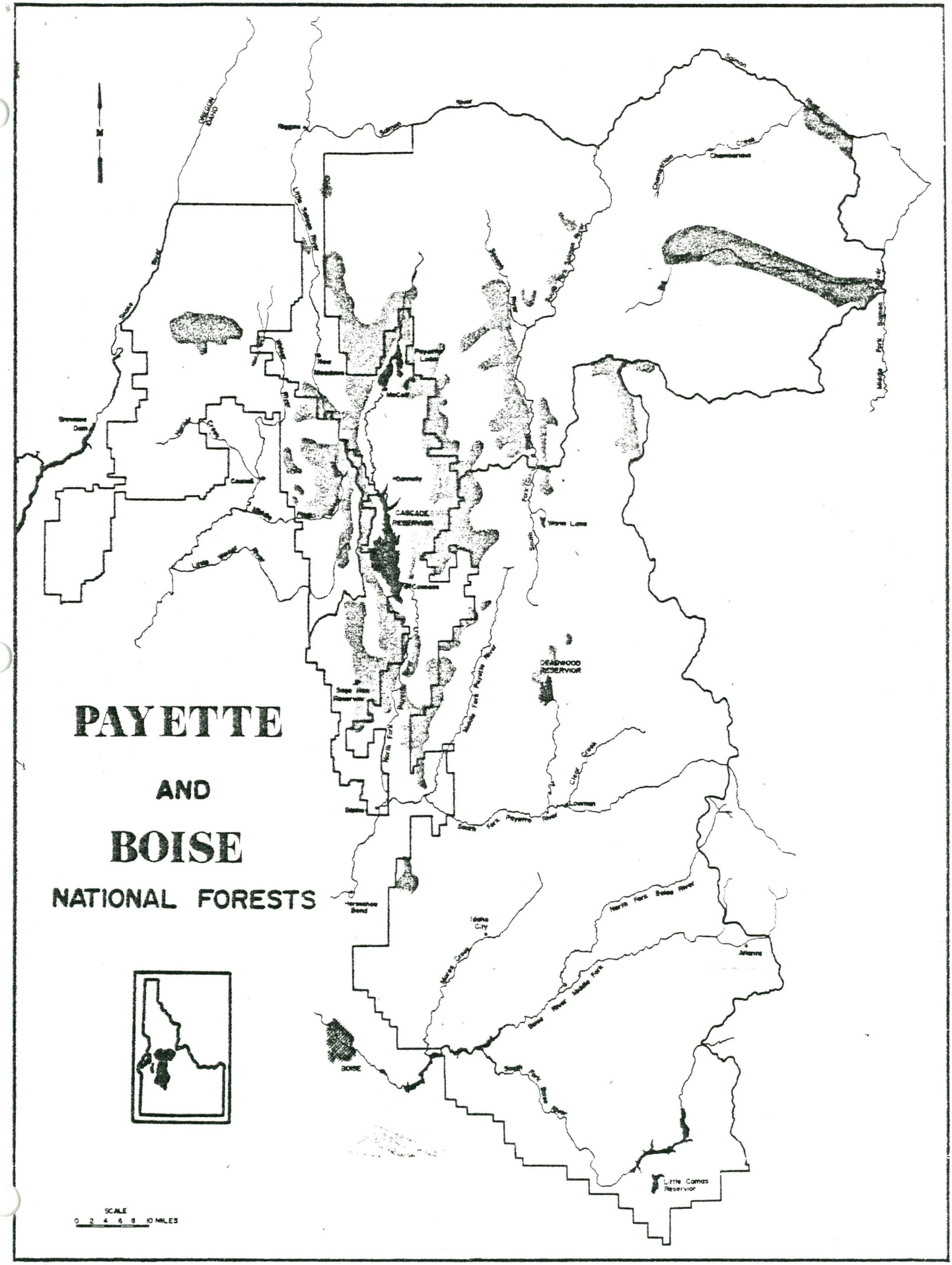

Figure 1. Area of defoliation by western spruce budworm, Boise and Payette National Forests and intermingled federal, state and private lands, 1978.

Three, 3-person crews were utilized to collect field data from late July through August. This was done according to survey techniques designed by FI&DM, Region 1, (Bousfield and Williams 1977) and the CANUSA Spruce Budworm Program. Sample stands, smaller in 1978 than in 1977, averaged approximately 30 acres. The number of plots per stand was determined using a ratio of one plot for each 5 acres of stand area, with a maximum of 20 plots per stand. Plot centers were established at 5 chain intervals along an azimuth determined from aerial photographs. Plots were permanently marked in 30 stands and can be revisited in 1979 or later to again check for damage by budworm.

At each plot center a variable (BAF 40) and a fixed (1/300th acre) plot was established. Variable plots provided information on tree species, dbh, height, and damage from defoliation by western spruce budworm of trees $\geq$ 5 inches dbh. Fixed plots provided tree species and defoliation damage on trees less than 5 inches dbh.

Defoliation by western spruce budworm was determined using different methods as prescribed by the CANUSA-West Handbook. First, current defoliation was estimated at mid-crown with binoculars and coded according to the scale shown below.

Defoliation	Code
0	0
1-25%	1
26-50%	2
51-75%	3
76-100%	4

As an additional check, current defoliation of buds was measured at mid-crown on the first two host trees encountered in the plot. This was done either by cutting four branches at mid-crown and rating 25 apical buds on each branch, or, using binoculars, to measure defoliation on 100 buds as seen from the ground. Whichever method was used each bud was assigned a defoliation value. A 1-4 scale was used which excluded the "0" code (0 to 25% was coded "1"). The total of 100 buds was divided by four and this value recorded.

Past defoliation was also estimated at three crown levels: upper, mid and lower. These estimates were assigned values from the following table.

Past Defoliation	Code
No past defoliation visible, current defoliation may be present.	0
Past defoliation visible, needle complement 1-25% of normal.	1

Past Defoliation	Code
Past defoliation conspicuous, needle retention poor, 25-50% of normal.	2
Past defoliation very conspicuous. Less than 80% of normal needle complement.	3

Top kill was recorded by two methods. On trees measured for height, the amount of dead was calculated directly with a Relaskop. On trees not measured for height, dead top was recorded as a percent of the crown, estimated by comparing amount of dead top to tree height.

Since periodic annual increment was desired, the last ten years' radial growth was measured to the nearest 1/100 inch on each tree sampled for height. These were the first four trees recorded on the variable plot. In most stands radial growth measurements were also recorded to cover the current infestation period. An equal set which covered the period of growth just prior to the outbreak was also recorded for covariance testing. Using these values, growth loss caused by western spruce budworm was estimated. Expected periodic annual increment is computed if the difference between the host (grand fir, subalpine fir, Douglas-fir, and spruce) and non-host (ponderosa pine, lodgepole pine, and white pine) adjusted mean growth is significant when tested by covariance analysis. As larch is a host for both western spruce budworm and larch casebearer, it was not sampled for radial growth.

This evaluation was designed to provide information to forest resource managers in central Idaho on effects of western spruce budworm. Stands have been grouped into Analysis Units which are composites of numerical values depicting defoliation intensity over time. Five Analysis Units have been arbitrarily chosen to rank defoliation over the infestation period from none to severe. During the annual aerial sketch mapping survey of the Intermountain Region, defoliation is rated light, moderate, or heavy. By assigning a value of 1 = light, 2 = moderate, and 3 = heavy, affected areas of forest are numerically rated for defoliation intensity. Cumulation of intensity ratings over time can help to display how areas have been affected during the infestation period. For instance, a stand heavily defoliated (3) for nine years (9) would have a value of (3 x 9) = 27 and fall into the severe category. This technique provides a general stratification of budworm damage. However, particular stands and trees may vary considerably in damage within different Analysis Units.

TABLE 1. IMPACT OF DEFOLIATION BY WESTERN SPRUCE BUDWORM ON TREES ≥ 5 INCHES DBH BY ANALYSIS UNIT AND DAMAGE CLASS BOISE-PAYETTE INFESTATION 1978 (Average-Trees/Acre).

ANALYSIS UNIT (AVE.)	SPECIES	GREEN	LIGHT DEF.	MOD. DEF.	HEAVY DEF.	LIGHT T.K.	MOD. T.K.	HEAVY T.K.	DEF. MOR.	OTHER MOR.	TOTALS
UNIT ONE	Grand Fir	9	48	0	0	0	0	0	0	0	57
	All Sp.	202	63	1	0	0	0.3	0	0	1	267
UNIT TWO	Grand Fir	13	72	26	6	2	1.6	0.6	0	1.7	118.7
	All Sp.	69	82	36	6	3	1.6	0.6	0	6	199
UNIT THREE	Grand Fir	1	14	57	27	14	3	0.5	2.5	0.7	102
	All Sp.	47	19	86	44	14	3	0.5	2.5	17	216
UNIT FOUR	Grand Fir	0	2.7	17	19	5	4	1.3	0	0	38
	All Sp.	36	16	72	74	23	14	1.3	0.7	1	200
UNIT FIVE	Grand Fir	1	26	74	7	0	44	0	16	3	127
	All Sp.	15	49	77	7	0	44	0	31	4	184
UNITS 3-4-5	Grand Fir	0.6	10	40	21	8	8	0.8	2.8	0.7	75
	All Sp.	38	21	78	54	16	13	0.8	5	3.7	203

1/ DEF. - Defoliation as observed during ground survey.

2/ T.K. - Top kill from defoliation by western spruce budworm.

3/ MOR. - Tree mortality from defoliation by western spruce budworm.

At each plot center, habitat type was determined as required for computing periodic increment. A comparison of budworm damage between the more common habitat types was made. The types compared were Abies grandis/Spirae betulifolia (Abgr/Spbe) in 5 stands, A. grandis/vaccinium globulare (abgr/Vagl) in 12 stands, A. grandis/Clintonia uniflora (Abgr/Clun) in 12 stands, and A. grandis/Acer glabrum (Abgr/Acgl) in 8 stands. At this time no significant difference could be detected. However, types (Abgr/Acgl) and (Abgr/Clun) did show slightly more damage. Perhaps with a larger sample a significant difference could be detected in other types. According to Knopf 1977b, types with most budworm activity were (Abgr/Acgl) and (Abgr/Clun) as well as A. grandis/Coptis occidentalis (Abgr/Cooc), and A. grandis/Linnaea borealis (Abgr/Libo).

Fixed Plots (< 5" dbh)

Combination of data from Analysis Units 3, 4, and 5 for fixed plots (Table 2) shows 539 trees per acre < 5" dbh. Grand fir comprised 55 percent of the stems (297 T/A), Douglas-fir 8 percent (44 T/A), Engelmann spruce 13 percent (72 T/A) and subalpine fir 23 percent (118 T/A). Top killing was recorded in 2.8 percent of the stems (15 T/A) and mortality in 4.6 percent (25 T/A). Considering impact of defoliation on individual tree species for trees < 5" dbh, subalpine fir and Engelmann spruce displayed no top kill or mortality. However, grand fir displayed 3 percent top kill and 7.2 percent mortality, and Douglas-fir had 13.7 percent top kill with 10.6 percent mortality.

Growth Loss

Growth loss was computed for each stand by tree species and two size classes using data from increment core and top kill measurements. Table 3 shows growth loss for grand fir and all species by Analysis Unit and stand. Analysis Unit 5 shows grand fir growing 86.5 percent of normal. This represents a loss of 32 BF/A/Yr. The grand fir in Unit 4 was growing 93.9 percent of normal with 19.5 BF/A/Yr growth loss. Analysis Unit 3 grand fir was growing 96.7 percent of normal with an average 12.5 BF/A/Yr growth loss. For grand fir the lowest recorded percent of normal growth was 80.6 percent and the greatest volume loss was 75.5 BF/A/Yr.

DISCUSSION

Surveys to determine impact to stands from defoliation by western spruce budworm in the Boise and Payette National Forests and other intermingled lands have been conducted in 1976, 1977, and 1978. A resume' of results from these surveys in terms of top kill and mortality for stands moderately, heavily and severely defoliated by western spruce budworm is given in Tables 4 to 7.

TABLE 2. TOP KILL FROM DEFOLIATION BY WESTERN SPRUCE BUDWORM ON TREES < 5 INCHES DBH BOISE-PAYETTE INFESTATION 1978.

ANALYSIS UNIT	GRAND FIR			TOTAL	ALPINE FIR			TOTAL	SPRUCE			TOTAL	DOUGLAS-FIR			TOTAL	TOTALS			TOTAL
	TOP KILL				TOP KILL				TOP KILL				TOP KILL				TOP KILL			
	T/A	%a*	%b**		T/A	%a	%b		T/A	%a	%b		T/A	% a	%b		T/A		%b	
UNIT ONE	0	0	0	611	0	0	0	60	0	0	0	0	0	0	0	1403	0		0	2699
UNIT TWO	30	0.5	0.3	5629	75	7.1	0.7	1050	0	0	0	978	0	0	0	1466	105		1.0	11039
UNIT THREE	75	1.9	1.5	3980	0	0	0	260	0	0	0	0	150	29.4	3.1	510	225		4.6	4900
UNIT FOUR	150	5.1	1.9	2940	0	0	0	2700	0	0	0	1800	0	0	0	485	150		1.9	7985
UNIT FIVE	0	0	0	500	0	0	0	0	0	0	0	0	0	0	0	100	0		0	600
TOTAL UNIT 3-4-5	225	3.0	1.7	7420	0	0	0	2960	0	0	0	1800	150	13.7	1.1	1095	375		2.8	13485
AVERAGE T/A	9			297	0			118	0			72	6			44	15			539

* %a Percent top kill compared to trees of same species in this unit,
** %b Percent top kill compared to all trees in this unit.

TABLE 3. GROWTH LOSS FROM DEFOLIATION BY WESTERN SPRUCE BUDWORM TO 48 STANDS, BOISE-PAYETTE INFESTATION 1978

	#	STAND NAME	GRAND FIR % of normal	GRAND FIR Growth loss CF/A	ALL SPECIES % of Normal	ALL SPECIES Growth loss CF/A
ANALYSIS UNIT ONE	C14	Fish Lake	———	———	100.0	0.0
	D24	038-008	100.0	0.0	100.0	0.0
	D25	038-011	100.0	0.0	100.0	0.0
	D29	073-011	100.0	0.0	100.0	0.0
	E16	492-106	0.0	0.0	100.0	0.0
	H01	Hawley Mtn.	100.0	0.0	99.3	0.4
		TOTAL	400	0.0	599.3	0.4
		AVE.	100	0.0	99.9	0.1
ANALYSIS UNIT TWO	A13	Little Mud	94.9	5.1	94.2	6.8
	A14	East Branch	92.1	4.2	95.1	4.2
	A34	Lost Creek	100.0	0.0	98.0	1.2
	A36	Round Valley	100.0	0.0	100.0	0.0
	C07	Cabin Cr. Campgd.	100.0	0.0	100.0	0.0
	C10	Mica Creek	100.0	0.0	100.0	0.0
	D08	Ecks Flats	100.0	0.0	100.0	0.0
	D23	038-001	100.0	0.0	100.0	0.0
	D26	043-003	100.0	0.0	100.0	0.0
	D27	054-011	100.0	0.0	100.0	0.0
	D28	055-001	100.0	0.0	100.0	0.0
	D30	078-008	100.0	0.0	100.0	0.0
	D31	079-012	100.0	0.0	100.0	0.0
	E04	McCall Airport	0.0	0.0	100.0	0.0
	E14	455-102	100.0	0.0	100.0	0.0
	E15	485-101	100.0	0.0	100.0	0.0
	H02	Hawley Mtn.	0.0	0.0	100.0	0.0
		TOTAL	1487.0	9.3	1687.9	12.2
		AVE.	99.3	0.6	99.5	0.7
ANALYSIS UNIT THREE	A03	Bull Horn	98.0	1.7	98.7	1.6
	A17	Twin Fork Cr.	96.8	2.9	97.0	2.9
	A23	West Branch	88.0	7.2	92.3	7.1
	C04	N. Bus. Mtn.	100.0	0.0	100.0	0.0
	C05	No Bus. Canyon	100.0	0.0	100.0	0.0
	D10	Pay. Lk. Ski Area	100.0	0.0	100.0	0.0
	D20	Bear Basin	87.0	10.0	88.9	10.0
	E01	Pay. Lk. Fall	96.4	2.8	97.2	2.8
	E10	Paddy Flat	100.0	0.0	100.0	0.0
	E13	Kennally Creek	100.0	0.0	100.0	0.0
		TOTAL	965.8	24.6	974.1	24.4
		AVE.	96.7	2.5	98.1	2.4
ANALYSIS UNIT FOUR	B04	Brown Cr. Road	0.0	0.0	100.0	0.0
	B10	Last Chance	———	———	100.0	0.0
	B12	Thorn Creek	91.1	1.8	97.8	1.7
	B17	Brundage Mtn.	———	———	100.0	0.0
	B19	Granite	89.7	15.1	91.6	15.1
	D01	Bear Basin	100.0	0.0	100.0	0.0
	D02	Bear Basin	94.9	3.4	89.5	17.1
	D03	Bear Basin	86.5	4.8	91.7	18.5
	D21	Payette Lake	100.0	0.0	96.9	2.9
	D22	McCall Lake	94.3	4.7	95.2	4.7
	E03	Little Pay. Lk.	100.0	0.0	100.0	0.0
	E07	Paddy Creek	88.8	5.5	91.8	8.3
		TOTAL	845.3	35.3	1154.5	68.3
		AVE.	93.0	3.9	95.5	5.7
ANALYSIS UNIT FIVE	B13	Thorn Creek	93.9	3.8	94.6	3.8
	F01	Split Creek N.	80.6	9.2	88.8	9.1
	F02	Split Creek S.	81.2	6.4	92.7	6.5
		TOTAL	255.7	19.4	276.1	19.4
		AVE.	86.5	6.5	91.8	6.5

TABLE 4. PERCENT TOP KILL IN TREES ≥ 5" DBH BY YEAR AND TREE SPECIES

Tree Species	1976	1977	1978
GF	29	37	23
AF	2	36	21
S	2	12	17
DF	1	9	4

General information taken from variable plots (trees ≥ 5" DBH) for the three years:

1976	207	Trees/Acre		23,741	BFA		34%	Top	Kill	(70	Trees/Acre)	
1977	145	"	"	27,363	"		23%	"	"	(33	"	")
1978	203	"	"	22,607	"		15%	"	"	(30	"	")

TABLE 5. PERCENT TOP KILL IN TREES < 5" DBH BY YEAR AND TREE SPECIES

Tree Species	1976	1977	1978
GS	6	30	3
AF	-	34	-
S	1	-	-
DF	1	10	14

General information taken from fixed plots (trees < 5" DBH) during the three surveys:

1976	791	Trees/Acre		8%	Top	Kill	(63	Trees/Acre)	
1977	788	"	"	20%	"	"	(157	"	")
1978	539	"	"	3%	"	"	(15	"	")

TABLE 6. PERCENT TOP KILL IN TREES ≥ 5" DBH BY YEAR AND TREE SPECIES

Tree Species	1976	1977	1978
GF	1.1	1.0	1.8
AF	-	-	5.0
S	-	2.0	-
DF	-	-	-

General information on mortality from variable plots.

1976	0.07%	mortality	or 0.14	Trees/Acre	
1977	0.5%	"	" 0.9	"	"
1978	2.5%	"	" 5.0	"	"

TABLE 7. PERCENT MORTALITY IN TREES < 5" DBH BY YEAR AND TREE SPECIES

Tree Species	1976	1977	1978
GF	-	2	3
AF	-	21	-
S	-	5	-
DF	-	-	14

General information on mortality from fixed plots.

1976	0%	mortality	or 0	Trees/Acre	
1977	4%	"	" 29	"	"
1978	5%	"	" 25	"	"

Plots from which data have been taken during the three survey years have been newly established each year. This might partially explain why top kill and mortality have fluctuated from year to year. Crews were different each year; however, instructions for recording top kill have consistently been to record no top as being killed unless dead gray wood was exposed. Some top-killed trees have undoubtedly moved into the mortality columns, while in some lightly defoliated stands new leaders have been formed.

In 1978, most plots were established permanently to allow revisitation as needed for long-term effects of defoliation. These permanent plots should strengthen our estimates of top kill, radial growth slowdown and mortality.

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REFERENCES

Bousfield, W. E. and R. E. Williams. 1977. Impact of Spruce Budworm on the Nez Perce National Forest, Idaho, 1976. USDA-Forest Service, Forest Insect and Disease Management, Missoula, Montana. Rpt. 77-3.

Knopf, J. A. E., A. Valcarce, and R. Beveridge. 1977a. Western Spruce Budworm Biological Evaluation, Payette and Boise National Forests, 1976. USDA-Forest Service, Insect and Disease Control, Boise, Idaho, Rpt. R-4 77-2, 10 pp.

Knopf, J. A. E., A. Valcarce, and R. Beveridge. 1977b. Biological Evaluation, Western Spruce Budworm, Payette and Boise National Forests, 1977. USDA-Forest Service, Forest Insect and Disease Management, Boise, Idaho, Rpt. R-4 78-1, 9 pp.

Knopf, J. A. E., A. Valcarce, and R. Beveridge. 1979. Biological Evaluation, Western Spruce Budworm, Payette and Boise National Forests, 1978. USDA-Forest Service, Forest Insect and Disease Management, Boise, Idaho, Rpt. R-4 79-2.

Ollieu, M. M., L. Livingston, and W. E. Bousfield. 1977a. Western Spruce Budworm Impact Evaluation, Payette and Boise National Forests, and Idaho Department of Lands. USDA-Forest Service, Insect and Disease Control, Boise, Idaho. Rpt. R-4 77-3.

Ollieu, M. M., L. Livingston, and W. E. Bousfield. 1977b. Impact of Defoliation by Western Spruce Budworm, Boise and Payette National Forests and Intermingled Federal, State and Private Lands. 1977. USDA-Forest Service, Forest Insect and Disease Management, Boise, Idaho. Rpt. R-4 78-2, 10 pp.